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NATIONAL ACADEMY OF SCIENCES

Number 18 • December 1958

IGY BULLETIN

A monthly survey by the U. S. National Committee for the International Geophysical Year. Established by and part of the National Academy of Sciences, the Committee is responsible for the U. S. International Geophysical Year program in which several hundred American scientists are participating and many public and private institutions are cooperating.

Program in Biological and Medical Sciences, 1958–1959

The Committee on Polar Research of the National Academy of Sciences and its Panel on Biological and Medical Sciences, in cooperation with the National Science Foundation, has prepared a broad program as part of the continuing US scientific research in Antarctic regions. The program, to be pursued primarily in the post-IGY period, is an outgrowth of the interest in life sciences that developed during the course of IGY studies in the physical sciences in this remote area. Australia, Great Britain, Argentina, and other nations are also supporting continuation of biological programs in the south polar regions. Of the twelve US scientists participating in this program, three will remain and continue their work during the austral winter.

At the US Naval Air Facility, on Ross Island in McMurdo Sound, a permanent laboratory will be installed by 1959 to support field studies in biology, medicine, and other life sciences in the coming summer season. In addition to a wide variety of equipment, biological supplies, and culture media, the laboratory will have a library of standard references, special texts, and the scientific reports of past Antarctic expeditions as well as current materials pertinent to Antarctic research.

Human Medicine

Medical studies of the incidence of respiratory infections, the isolation of the organisms responsible for such infections, and the development of new field techniques for their control are being carried out by a medical team supervised by William J. L. Sladen, Johns Hopkins University, Baltimore, Maryland. These studies are being made at the joint New Zealand-United States Hallett Station, at Wilkes Station, and at NAF, McMurdo. The medical team is using a temporary laboratory on board the USS *Staten Island* until the laboratory at NAF, McMurdo is completed. Robert M. Chanock, Respiratory Unit, National Institutes of Health, Bethesda, Maryland, will cooperate in phases of the work to be conducted in the United States. Rainer Goldsmith is conducting the laboratory investigations on board the *Staten Island.*

Ornithology

Ornithological work includes studies of the breeding biology of Antarctic birds, particularly of penguins, the south polar skua, and the giant petrel. The birds are also banded for study of their migration habits. These investigations are partly extensions of the research conducted by Carl Eklund while Station Scientific Leader at the US-IGY Wilkes Station during the 1957–58 period, and of studies initiated by Sladen during his period of Antarctic service with the Falkland Islands Dependencies Survey (UK) on the Palmer Peninsula.

At Wilkes Station, a year-long study of

the social and parental behavior of the Adélie penguin, and of its orientation mechanism in migration, is being undertaken. This research is conducted by Richard Lee Penney, graduate student at the University of Wisconsin, Madison, Wisconsin. Penney is one of the three Americans who will winter over at this station.

Penney is also collecting samples of egg white for C. G. Sibley, Cornell University, who is making a taxonomic study of avian proteins under a National Science Foundation grant.

Animal Parasitology

Parasitological studies of birds and mammals will be made, principally at the IGY Hallett and Wilkes Stations and at NAF, McMurdo. In addition to collections of internal parasites of seals and birds, Sladen and Goldsmith are making a special collection of birds' heads and necks. These will be returned to the United States for study by Gordon M. Clark, biologist and authority on mites inhabiting the respiratory passages of birds. He will study the specimens at the Patuxent (Md.) Research Refuge of the US Fish and Wildlife Service.

Entomology

In the field of entomology, an investigation of land invertebrates is being carried out by Madison E. Pryor, graduate student at the University of Tennessee, Knoxville, Tennessee. He will work at the biological laboratory at NAF, McMurdo. Pryor is one of two biologists who will winter over at McMurdo.

Botany

A special study of Antarctic mosses is being made during the austral summer by Elmer G. Worthley, Sr., Arctic Institute of North America, in the region of Ross Island, McMurdo Sound.

Marine Biology

Marine biology studies are being conducted by six investigators working partly from ships and partly from the laboratory at NAF, McMurdo. A study of the food cycle of marine fauna is being made at Hallett Station and at NAF, McMurdo. It will be continued, by invitation from the New Zealand Oceanographic Institute, aboard the New Zealand oceanographic research vessel HMNZS *Endeavour* during a cruise along the Antarctic convergence zone and in the Ross Sea. (The convergence zone is the region in which the cold waters of the Antarctic current sink beneath and mix with warmer waters of the West Wind Drift.) This work will be carried out by Richard G. Miller, of Long Beach State College, Long Beach, California. He will be assisted by John Resek, Jr., Costa Mesa, California.

Donald E. Wohlschlag, Chairman, Department of Biological Sciences, Stanford University, is studying the ecology of inshore marine invertebrates at NAF, McMurdo. John H. Dearborn, graduate student at Stanford, is assisting him. Dearborn will continue these studies at the biological laboratory at McMurdo during the winter.

Hugh H. DeWitt and James C. Tyler, also graduate students at Stanford University, are accompanying, respectively, the USS *Glacier* through the Ross Sea to McMurdo Sound, and the USS *Edisto* to IGY Ellsworth Station on the Weddell Sea. Under the direction of Wohlschlag, they are carrying out studies on the systematics, or classification, of Antarctic fishes and making other marine biological observations. Particular study is being made of the physiological properties of blood and of anatomical adaptations to feeding habits and habitat.

Tyler is also collecting sera from Antarctic fishes for the Serological Museum at Rutgers University.

Psychology and Psychiatry

An analysis of selection and performance data of wintering-over personnel, based on diary materials, psychiatric evaluations, and interviews, will be conducted by William M. Smith, graduate student at George Washington University, Washington, D. C. The purpose is to evaluate factors that may be useful in selecting scientific personnel for future work in isolated regions; to report on the performances of scientific personnel during their stay in the Antarctic; and to describe the group structure at the scientific stations and the roles played by the individual members of the various scientific parties.

IGY News From Other Countries

A. Progress of the United Kingdom Program

The following account is based on summary reports of the first twelve months of the United Kingdom IGY Program. The reports were presented by the British National Committee for the IGY to the Fifth General Assembly of the IGY, held in Moscow, July 30–August 9, 1958.

The United Kingdom Program, which includes all IGY disciplines, got under way promptly with the start of the IGY on July 1, 1957, and has proceeded according to plan. The activities of the first twelve months produced many significant results. Among them are the discovery of a southward-flowing countercurrent in the eastern Atlantic similar to the one found earlier beneath the Gulf Stream; correlations between auroral activity in the northern and southern hemispheres, and, in the Antarctic, between the aurora and geomagnetic and ionospheric activity; and observations of two distinct radio-wave-reflecting structures in the F layer of the Antarctic ionosphere.

In the Antarctic, the most extensive United Kingdom program is concentrated at the Royal Society IGY Station, at Halley Bay on the eastern side of the Weddell Sea. Here, the entire scientific program, comprising investigations in meteorology, geomagnetism, aurora, ionospheric physics, glaciology, and seismology, was functioning by June 20, 1957.

(Other United Kingdom Antarctic stations are maintained on the Palmer Peninsula and in the South Shetland and South Orkney Islands, near the northern end of the Peninsula. Shackleton Station, on the Filchner Ice Shelf, and South Ice Station, on the polar plateau between Shackleton and the South Pole, although established primarily as bases for the Commonwealth Trans-Antarctic Expedition, also supported programs of scientific investigation—in meteorology and glaciology, in particular.)

Meteorology

In addition to the standard meteorological program, British Ocean Weather Ships in the Atlantic are recording solar radiation. Ozone sounding equipment of the electrolytic-absorption type has been flown on balloons released at Halley Bay, at Malta, and in England, providing data on the vertical distribution of ozone to altitudes of about 20 km. A rapid rise in total atmospheric ozone was observed at Halley Bay in late October 1957; a similar increase occurred just one year earlier.

In the meteorology program at the Royal Society Station, standard surface measurements, including temperature, pressure, humidity, and wind speed and direction, are made continuously or at frequent, fixed

intervals. The lowest temperature recorded since establishment of the station was −51°C (−60°F), in July 1957; the highest was 2°C (36°F), in January 1957. A wind speed of 77 knots, almost 90 mph, was recorded in June 1957.

Standard surface observations were made on the Commonwealth Trans-Antarctic Expedition and at Shackleton and South Ice Stations during most of 1957.

Glaciology

The glaciology program includes studies in the Antarctic and in glacier regions of tropical East Africa. An expedition by Sheffield University scientists to Mt. Kilimanjaro was completed in January 1958, and other expeditions to East African glaciers were included in the 1958 program. Field work has been completed on South Georgia Island in the South Atlantic, and glacier-regime studies and other observations have been made in the Falkland Islands. Glacier fluctuations relative to climate during the past 50 years were included in the South Georgia studies.

Royal Society Station: Glaciological investigations during the first twelve months at the Royal Society Station, which lies on a partly grounded ice shelf several hundred feet in thickness, were limited to studies of accumulation and ablation in the vicinity of the station, of temperature gradient within the ice, and of past variations in the net accumulation. Studies of related meteorological factors were made simultaneously. These included radiation balance, heat transfer and variation of temperature in the near-surface layers, and snowfall.

Snow accumulation was measured by use of stakes and in a small pit. Meteorological data served as a guide to the dating of wind crusts and snow deposits. These accumulation measurements were correlated with others made on sledge trips to points as far as 30 mi from the station. Annual accumulation back to 1943 averages 38 cm, with a large total range of 18 to 77 cm.

The report adds that "the detailed notes on the layers appear to provide useful evidence of the meteorological characteristics of each year, for example of the frequency of 'warm periods' in the winter. In several of the summers there is no indication that melting occurred."

Study of the general characteristics of the ice shelf and of the sources which feed it was made by air reconnaissance. The positions of ice-fall areas and crevasses gave some indication of the location and configuration of the coastline proper. The rate of movement of the shelf ice appears to be very slight, but definite.

Commonwealth Trans-Antarctic Expedition: Seismic soundings to determine the thickness of the ice sheet and the nature of the underlying materials were made at 30–70 mi intervals from South Ice Station to the Skelton Glacier. Ramsonde measurements were made frequently and the cores examined. At seismic stations, temperatures were measured at one-meter intervals, to a depth of 11 meters, in the ramsonde holes.

At South Ice, snow accumulation was measured and a study of the effects of the surface micro-climate on accumulation and ablation was made. A 50-ft-deep snow pit was dug for studies of ice-crystal orientation and snow strata. A 3-in bore hole drilled from the bottom of the pit extended these observations to a depth of 100 ft.

Oceanography

United Kingdom research vessels cooperated with vessels of the Woods Hole Oceanographic Institution in the discovery and investigation of a southwest-flowing countercurrent beneath the Gulf Stream (see *Bulletin Nos. 2* and *8*). Detailed measurements were also made, in collaboration with Woods Hole, of the temperature, salinity, oxygen, and other variables across the Atlantic at 24°, 32°, and 48°N latitude.

Cooperative investigations with Norwegian and French research vessels have revealed another countercurrent about 640 km (400 mi) west of Oporto and Lisbon,

Portugal. It flows southeastward at speeds of 1.5 to 3 km (1 to 2 mi) per day below a depth of 1400 m (about 4600 ft). Other deep-water studies have been made in the Atlantic west of the English Channel; in the Straits of Gibraltar, Bab-el-Mandeb (between the Red Sea and the Gulf of Aden), and Hormuz (between the Persian Gulf and the Gulf of Oman); and by British weather ships.

In the Antarctic, gravimeter records for Shackleton Station show the rise and fall of the 1300-ft-thick Filchner Ice Shelf with the tide. The report states that "No other method of tidal observation at the head of the Weddell Sea was practical owing to the great depth of the sea (500 fathoms) at the edge of the ice shelf."

Geomagnetism

In the Antarctic, an effort is being made to measure the water currents and associated electrical currents in the Weddell Sea below the edge of the Filchner Ice Shelf. Thus far, the records have failed to show any geomagnetic effects related to such electrical currents.

Aurora

Significant results have been obtained in the aurora program at the Royal Society Station, where auroras were observed on all dark, clear nights. The report states that considerable auroral activity occurred north of the zenith, and there were many full coronas with centers usually 118° above the southern horizon. At times, auroras were seen within 10° of the northern horizon; this corresponds to overhead displays at a position roughly 29° from the geomagnetic pole, if it is assumed that the aurora is 100 km above the earth's surface.

". . . the impression gained was that for flaming diffuse surfaces without any rayed structure the motion of the waves of luminosity was directed along the local geomagnetic meridian [rather than toward the magnetic zenith]. . . . When rays were present the waves appeared to move towards the magnetic zenith but this is the effect to be expected when waves of excitation cut across the rays at an angle. It is concluded that in all cases the direction of motion was along the geomagnetic meridian but that the presence of a rayed structure produced a disturbance."

Comparison of auroral data with radio-echo data: The Royal Society Station is equipped with radio-echo apparatus similar to that at the Jodrell Bank Experimental Station at the University of Manchester, England. Although echoes occur much more frequently at the Antarctic station, their general features appear to be the same at both stations.

No correlation was found between specific auroral forms and the sharpness of the radio echoes. Moreover, the fact that echoes are not always received when quiet arcs are present suggests that ionization of sufficient density to cause reflection is associated only with the more active auroral forms.

Comparison of the Halley Bay radio-echo data with similar data for the same period at Jodrell Bank suggests the conclusion ". . . that the great aurora of the northern hemisphere are accompanied simultaneously by a greatly enhanced activity of the aurora australis."

Comparison of auroral data with magnetic data: Since the Royal Society Station is some distance from the auroral zone, auroras are usually highly active by the time they have moved overhead. This hinders direct correlation with simultaneous magnetic disturbances. Nevertheless, the report states, "There are . . . indications that the vertical magnetic disturbance force does not change sign when arcs and draperies pass through the zenith, as should happen if the magnetic disturbance is due to an east-west current flowing along the base of the arc. On the contrary, large vertical disturbances were sometimes observed when a drapery passed overhead. More detailed analysis will be necessary before any definite conclusions may be drawn on this point."

Ionospheric Physics

The program is in general being carried out as planned and the flow of data to the World Data Center C subcenter for Ionospheric Data, at Slough, England, is rapidly increasing. A large volume of all types of ionospheric data has been received from the Royal Society Station in the Antarctic.

Ionospheric measurements at Halley Bay indicate that the station is situated outside the auroral zone. The main features of the daily F-layer variation (layer which reflects high-frequency radio waves) over Halley Bay were:

"(a) . . . very large diurnal variation in the electron density with a maximum near noon in winter despite the absence of significant photo-ionization from the sun.

"(b) . . . suddenness of the change from typical winter to typical summer variations which occurs near the equinoxes.

"(c) . . . small diurnal variation in the electron density in summer which shows a maximum near midnight and a minimum near noon.

"These features are consistent with the hypothesis that the diurnal variations of the F2 layer at Halley Bay are mainly determined by movements of ionization and not by the primary photo-ionization processes."

The report further states that winter-month ionograms show two distinct reflecting structures in the F region ". . . at times between about 1900 LMT [Local Mean Time] and 0200 LMT. One of these is continuous with the dense layer present on the previous noon and the other, . . . first seen at oblique incidence, gradually replaces the former and eventually develops into the dense F layer of the subsequent noon period. The new structure is sometimes first seen at appreciably lower heights than the old F layer and it then gives rise to striking discontinuities in the diurnal variations of the density and height of the layer. . . . The earth's magnetic field at Halley Bay shows unusual fluctuations while this movement is taking place. . . . The new layer is generally dominant before the . . . main period of corpuscular activity, . . . between 0200 and 0900 LMT, and . . . the noon F2 critical frequencies in midsummer and midwinter are practically equal."

In the vicinity of the Royal Society Station, there appears to be very good correlation between auroral and ionospheric activity. Preliminary reports indicate that auroras occurring at the zenith are accompanied by severe radio blackouts.

Daily radio-wave absorption measurements indicate the presence of a sporadic, corpuscle-controlled absorbing layer in the ionosphere along with the normal, solar-photon-controlled absorbing layer. This sporadic layer is densest and occurs most frequently near 0400 LMT, the time of maximum occurrence of total blackouts. Moreover, the daily variation of the sporadic layer is similar to that of the blackouts.

Considerable activity is also shown at 0400 LMT by the radio-echo index, but its daily variation is, in general, shifted to earlier hours. This was unexpected, as similar measurements in the northern hemisphere show a shift to later hours.

Solar Activity

A heliograph for analysis of the Hydrogen-alpha radiation of the sun commenced operation at the Cape of Good Hope in March 1958. This instrument is providing full information for about 30 solar flares each month. The films produced by the heliograph are being analyzed photometrically, and light curves have been prepared for a number of solar flares.

Rockets and Satellites

As the program progressed there was a substantial expansion of effort in the field of rockets and satellites.

Satellites: Working groups on optical (visual and photographic) and radio (including radar) tracking were set up and arrangements made for observation of earth satellites passing over the United Kingdom. Similar arrangements were made at the Uni-

versity College of Ibadan, Nigeria, and at the Radio Research Substation, Singapore.

The photographic and visual observations are being made both at observatories and by amateur astronomers. Radio observations, including doppler studies, and signal-strength measurements have been made at nine or more stations; interferometers and direction-finding equipment are also in use at these stations. Radar observations have been made at Jodrell Bank. Telemetry equipment for recording data from United States earth satellites, loaned by the US-IGY Committee, is operated at Ibadan and Singapore; telemetry signals from USSR satellites have been recorded by the BBC receiving station at Tatsfield, England, and by amateur radio observers.

United Kingdom agencies are issuing orbital predictions for earth satellites.

Rockets: A high-altitude rocket, the "Skylark," has been developed for upper-atmosphere research. Following the first IGY launching at Woomera, Australia, on April 17, 1958, several successful additional launchings have been made. Although the results are still being analysed, "... one interesting phenomenon, believed to be due to the presence of atomic oxygen, is the development of an intense luminescent cloud lasting 3 to 4 minutes from the explosion of the highest sound-ranging grenade at about 120 km [75 mi], ... it is hoped in further experiments to study wind distribution by this means."

Seismology

In Britain, a number of stations are compiling and transmitting seismic data, including observations of microseisms. Eight stations in the West Indies, the Royal Society Station in Antarctica, and a station at Port Stanley, Falkland Islands, are also contributing data.

Small earthquake shocks are recorded frequently at the Royal Society Station. These appear to be local, possibly associated with mountains within a few degrees of the station. According to the United Kingdom report, "No other seismic activity has been traced to the Antarctic continent."

Gravity

A gravity traverse was carried out during the Commonwealth Trans-Antarctic Expedition from Shackleton Station (UK), on the Weddell Sea, via the South Pole to Scott Station (NZ), on McMurdo Sound. Measurements of relative gravity were made with a Worden gravimeter after each camping period and at intervals of about 15 mi along the 2150-mi traverse route. Similar measurements were made at the Royal Society Station.

With US cooperation, the Cambridge University Department of Geodesy and Geophysics made a series of pendulum gravity measurements early in 1958 at eight stations between Teddington, England, and Johannesburg, South Africa. Another such series was planned for 1958 between Washington, D. C., and South America.

Earth tides are being recorded continuously at Winsford, Cheshire, England. The records are sent to Bidston Observatory for reduction and analysis.

B. Antarctic Notes

The following review of plans by 12 nations for scientific activity in Antarctica during 1959 is based on a report in the CSAGI publication, IGY News. *The information for the report was supplied by the Acting Secretary of the Special Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions (ICSU). In general, it appears that research activity in the Antarctic during 1959 will continue at nearly the same level as that maintained during the IGY, which ends on December 31, 1958.*

Argentina: The scientific program at Ellsworth Station will be continued coopera-

tively by Argentine and US personnel; two US meteorologists will winter-over at Ellsworth Station in 1959 and remain through the 1959–60 Antarctic summer season. The program at General Belgrano Station, on the Filchner Ice Shelf, will continue on a limited basis; other Argentine Antarctic stations will continue at present levels.

Australia: The Macquarie Island, Mawson, and Davis Stations will be maintained. In addition, the program at Wilkes Station will be continued cooperatively by Australian and US personnel; two US meteorologists and one US biologist will be at the station through the 1959 winter and the 1959–60 summer seasons. Oversnow traverses will be conducted from Mawson during the 1958–59 summer season; they will then be transferred to Wilkes Station.

Belgium: The Roi Baudouin Station will remain in operation during 1959.

Chile: All present stations will be maintained in 1959, and the Risopatron Station, destroyed by fire in March 1958, will be rebuilt. Additional studies in geomagnetism, cosmic rays, geology, chemistry, biochemistry, and bioclimatology are planned.

France: The inland Charcot Station will be closed at the termination of IGY, but the D'Urville Station, on the coast, will continue to operate with only slight reductions in parts of the program.

Japan: Reoccupation of Syowa Station by a wintering-over party of 12–15 men is planned for February 1959. (The station was evacuated in the summer of 1957–58 because ice conditions made resupply impossible.) The party will resume the original program of observations in aurora and airglow, cosmic rays, geomagnetism, ionospheric physics, meteorology, glaciology, and seismology.

New Zealand: The program at Scott Station will continue; four US scientists will winter-over during 1959, remaining through the summer of 1959–60. Hallett Station will be operated jointly with the United States on a modified basis. The 1958–59 summer program will include studies in biology, geology, and oceanography; topographic surveying will also be carried out.

Norway: The present scientific program at Norway Station will continue in 1959.

South Africa: There are tentative plans to continue investigations on the Tristan da Cunha Islands, on Marion Island, and, subject to agreement with the United Kingdom, on Gough Island.

United Kingdom: Research in the major scientific disciplines will continue at Royal Society Station; eight other Antarctic stations will continue present programs. Extensive topographic and geologic surveys will continue in the Graham Land region, at the northwestern end of the Palmer Peninsula.

United States: Full operations will continue at the Byrd and South Pole Stations; at the Naval Air Facility, McMurdo Sound; and, in cooperation with New Zealand, at Hallett Station. Oversnow traverse operations will continue; they will be made primarily in Marie Byrd Land, but one is planned for Victoria Land during the 1958–59 summer season. Little America Station will remain in use for some purposes.

Soviet Union: All stations will be maintained except Pioneerskaya, which will be closed in January 1959. The program at Bunger Oasis will be reduced. It was hoped to transfer Sovietskaya Station to the "pole of inaccessibility" during October–November 1958. Additional traverses are planned, including one from Vostok Station to the US-IGY South Pole Station and back to Sovietskaya during the 1959–1960 summer season. It is also planned to establish additional small bases—one south of the Bellingshausen Sea and one in Queen Maud Land—for glaciological and meteorological studies and to assist in future traverses. Oceanographic investigations will continue in the Bellingshausen Sea and in the Antarctic Convergence region, to the north, as well as along the coast of Queen Maud Land.

Auroral Storm of February 10–11, 1958

The following report is based upon material supplied by J. R. Winckler, L. Peterson, R. Hoffman, and R. Arnoldy, School of Physics, University of Minnesota.

During the night of February 10–11, 1958, a very large auroral storm occurred. The storm and other related phenomena were especially well observed and reported, both visually and by a number of instrumental techniques.

Balloon-borne instruments at Minneapolis detected two groups of strong X-ray bursts during the storm. These coincided with two large magnetic bays (increases or decreases in the intensity of magnetic-field components, represented by bay-like indentations on graphs showing variations of magnetic intensity with time); with strong absorption of radio noise; and with the passage across the zenith of a very large amount of auroral luminosity. A cosmic ray decrease also accompanied the storm.

The University of Minnesota workers believe that these terrestrial disturbances were associated with the earth's entry into a large cloud of solar gases that may have originated in a solar flare occurring about a day earlier.

The Aurora

The aurora observed in North America during this storm was one of the most spectacular in recent years. It was reported as far south as Cuba. At Minneapolis, the aurora was seen by visual observers simultaneously with the sudden commencement of the magnetic disturbance, at 0126 UT February 11. The all-sky camera record from Hanover, N. H., shows its appearance a few minutes after the magnetic disturbance began. At Minneapolis, from 0130 to 0330 UT a very intense diffuse green arc covered the sky from 20° above the northern horizon to the zenith and from the eastern to the western horizon. The outstanding feature, however, was the red color, also very intense, which appeared in diffuse patches at high angles above the northern horizon and, at 0200 UT, covered the northern sky from 15–30° elevation as a diffuse arc.

The IGY Auroral Data Center at Cornell University has supplied the following table showing the southern limit of arc forms at one-hour intervals:

UT Feb. 11	00	01	02	03	04	05	06	07	08	09	10	11	12	13
Geomagnetic N Lat.	58	54	50	49	51	48	47	52	50	50	46	48	53	54

It is estimated that the aurora extended from a height of about 200 km to 800 km, and for a distance of about 9600 km east-west and 400 km north-south. In addition to the very high intensity of both the red and green spectral lines, other unusual features of the aurora were the diffuseness and extent of the luminescence, and its persistence for long periods without major changes in form.

Auroral forms or high auroral luminosity were also observed visually or recorded by all-sky cameras at Minneapolis, Fargo, N. D., and Yerkes Observatory, Williams Bay, Wisc., twice during the second phase of the storm. On the first occasion, movement was northward. On both occasions—beginning at 0620 and 0848 UT—they were exactly coincident (on the order of one minute) with the appearance of X-ray bursts, magnetic bays, and cosmic-noise absorption.

Related Solar Phenomena

Considerable solar activity was present for several days prior to the terrestrial storm; hence, the solar-terrestrial relationship is not completely certain. However, the outstanding solar event of the period was a flare, reported by Honolulu Observatory as Class 2; it started at 2108 UT February 9 and ended at 2302 UT the same day, with maximum phase at 2140. The flare was also observed by Sacramento Peak Observatory (N. Mex.), which classified it as 2+. Large radio-noise fluxes were reported by several stations during the flare.

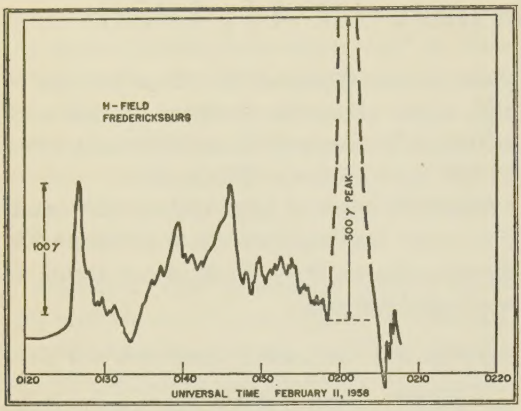

Fig. 1. *Trace of Rapid-Run Magnetogram at Fredericksburg Observatory for First Part of Auroral Storm of February 10–11, 1958. The 500 γ peak was accompanied by large earth-current disturbances.*

Magnetic Storm Phenomena

The terrestrial effects of this storm began at 0.125.7, ± .2, UT on February 11, according to the rapid-run magnetogram of Fredericksburg (Va.) Observatory. (Figure 1 shows the record of this instrument for the first phase of the storm.) The horizontal component (H) of the earth's magnetic field immediately showed a bay of +117γ (one gamma, γ, equals 1/100,000 gauss; the earth's total magnetic-field strength is about ½ gauss in middle latitudes). A second sharp, positive bay appeared at 0159.0, ±.1; it followed a disturbed period and was larger than the first, reaching a peak value estimated at about +500 γ. This sudden increase in the horizontal component (H) was accompanied by sharp drops of about 150 γ in the vertical component (Z) and 30 γ in the magnetic declination (D). It is assumed that these pulses represent the initial encounter of the solar gas cloud with the earth's dipole field, the sudden appearance of ionospheric current systems, or both. If one assumes a relative speed between the earth and the solar stream of 1400 km/sec, then a time lapse of 0.1 min for an appreciable change in H to occur corresponds to a relative movement of the solar stream of about two earth radii.

If the sudden commencement of the magnetic disturbance is associated with the solar flare that occurred at 2108 UT on February 9, the transit time is approximately 28 hours, indicating a speed of 1400 km/sec. This speed lies within the range of values often postulated for solar corpuscular streams. In addition, the over-all strength of the storm field, with bays of 1000 γ, below the auroral zone, classifies this storm as an extreme one.

Earth Currents: Large earth currents were observed coincident with the horizontal-component peak at 0159. A communication from T. E. Talpey, of the Bell Telephone Laboratory, Murray Hill, New Jersey, states that the earth's potential at the western end of the North Atlantic Telephone Cable dropped from a maximum of about 2650 volts at 0202 UT on February 11, through zero to a peak in the opposite direction at 0209 UT. The current was being driven from west to east through the cable. The section of cable between Clarenville and Sydney Mines, Nova Scotia, at about the same times as the peaks at the western end of the trans-Atlantic section, exhibited peaks of 1450 and, in the opposite direction, 1100 volts. The cable from northern Washington State to Alaska had a maximum of only 250 volts, and the California-Hawaii cable showed no major voltage changes.

The observed earth current peak seems to be an induction effect associated with the second, and largest, of the two magnetic peaks. According to the observations, the recorded current flow was from west to east, H increased, and Z decreased. The total storm field is a north vector increasing initially. The circuit loop of the earth current, if considered to lie in a vertical east-west plane, requires a return path through the sea *above* the cable. However, derivation of the potential in the water gives only about 15 volts around the circuit, compared to the measured maximum of 2650 volts. (The circuit cannot be closed *under* the cable as the polarity would be wrong for an induction effect associated with the horizontal-component bay.)

It is felt, therefore, that the earth current is apparently part of a system flowing in the earth's surface and associated with changes in the vertical component in an unexplained way. The current system seems to be centered over the eastern United States.

Remainder of Storm: The remainder of the magnetic storm was characterized by two large negative bays in the horizontal component (see Fig. 2). The bays were closely associated with the sudden appearance of intense auroral activity passing the zenith in the vicinity of Minneapolis.

Balloon Observations of Auroral X-Rays

Following the discovery of X-rays penetrating to balloon altitudes at Minneapolis during auroral storms on three occasions in 1957 (see *Bulletins 10* and *15*), attempts have been made routinely to prepare launchings when strong storms are forecast. A balloon launched at 0445 UT on February 11 encountered the first detectable X-ray bursts at 0622, coincident with the major decrease in the first large magnetic bay of the second phase of the storm; these bursts continued until 0730. A second large period of bursts occurred at 0850, coincident with the second magnetic bay of this phase (Fig. 2).

It is thought reasonable to assume that both the changes in conductivity of the ionospheric E-layer, which produced the magnetic bays, and the observed X-rays had a common origin in electrons produced by the solar gas stream. These electrons may be accelerated several earth radii from the earth by an interaction between the earth's dipole field and the neutral plasma from the sun. Their energies would lie in the range from 40–100 kv or higher; most of their energy, however, would be lost in the atmosphere as ionization and as the visible auroral light. About 1/1000 of the energy would be radiated as Bremsstrahlung X-rays (see *Bulletin No. 10*) the higher-energy components of which are detected at balloon levels (about 100,000 ft).

Cosmic Noise Absorption

The large absorption of cosmic radio noise at 18 megacycles/sec was observed exactly coincident with the magnetic bays and the X-ray bursts. The absorption was observed, at Boulder, Colorado, both with a vertically beamed antenna and with an interferometer

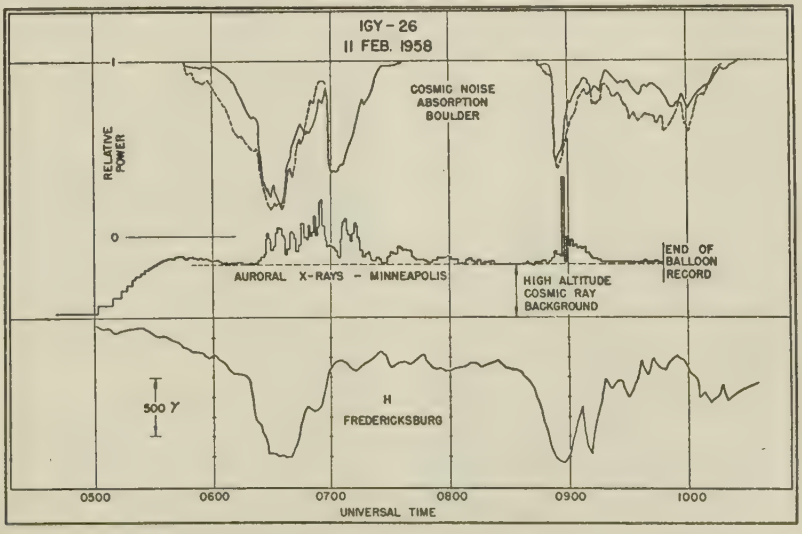

Fig. 2. *Comparison of Measurements of the Horizontal Component of the Magnetic Field at Fredericksburg, Auroral X-Rays at Minneapolis, and Cosmic-Noise Absorption at Boulder. Intense, widespread ionization appears to have occurred twice, at approximately 0630 and 0900 UT.*

directed at an elevation angle of 35° to the northeast. The similarity of the records is good evidence for a very widespread increase in ionospheric electron density extending north-south for at least 150 km. Heavy overcast at Boulder prevented direct observations of the aurora, but the correspondence, even in fine detail, of the fluctuations of the output of the two antennas implies simultaneous fluctuation of the primary phenomena over distances of hundreds of kilometers. Furthermore, the correspondence of data among Fredericksburg, Minneapolis, and Boulder (Fig. 2) shows that the major primary fluctuations were simultaneous over distances of thousands of kilometers.

Correlation of X-Rays, Magnetic Bays, and Cosmic Radio-Noise Absorption

The large changes in the magnetic-field H component, the strong cosmic-noise absorption, the auroral X-rays, and the general presence of the aurora itself, are all consistent with a very intensified bombardment of the ionosphere by high-energy electrons between 0530–0700 UT and 0830–0930 UT on February 11 over central United States.

It is assumed that cosmic-noise absorption during an auroral storm occurs mainly in the upper D-layer of the ionosphere, at altitudes of 80–90 km. Using a value of 6×10^6 electrons/cm^2/sec for the auroral electron flux, inferred from X-ray intensity and energy, the electron density in the upper D-layer at Boulder coincident with the February 10–11 aurora is computed to be 1.2×10^5 electrons/cm^3. This figure is in reasonable agreement with the value of 1.4×10^5 electrons/cm^3 obtained through cosmic-noise-absorption studies.

Visual estimates place the lower limit of the auroral luminosity at 200 km. If this marks the lowest level of penetration of the electrons or other primary ionizing agent, the accompanying radio-noise absorption must arise from the X-rays acting as a secondary ionizing agent—penetrating to much lower levels, ionizing the E and D layers, and appearing at balloon heights. Only 10^{-3} to 10^{-4} of the electron energy appears as Bremsstrahlung X-rays and only high-energy X-rays reach balloon levels; hence, the X-ray energy falls far short of the amount needed to account for the D-layer electrons causing the cosmic-noise absorption. Therefore, either the estimated height of 200 km was too high and the lower border of the aurora was actually at the usual height of 75–100 km, or electrons or other particles carried considerable energy downward, below the visual auroral border. Possibly, the visual luminescence is associated with protons at higher levels, while electrons constituting an equal or nearly equal current penetrate to lower levels producing the ionospheric effects without large amounts of visual luminosity.

The large magnetic bays observed at Fredericksburg coincident with the X-ray bursts may be attributed to an increased conductivity of the ionospheric E-layer, owing, probably, to the same ionizing agent that produced the cosmic-noise absorption phenomena.

Cosmic Ray Phenomena

The storm was accompanied by a worldwide decrease in the intensity of galactic cosmic rays. This is demonstrated by recordings of two groups of ground-level neutron monitors. One group is in Europe and Africa, close to the longitude of Greenwich, except for a station at Hobart, Tasmania (145°E), and the other is in the western hemisphere extending from Northern Canada to the Antarctic approximately along 90°W. All stations show an initial drop at 0200 UT on February 11 of roughly the same amount—4 to 6%.

(This is considered to be a well-documented example of a phenomenon discovered by S. E. Forbush. Usually it is characterized by a sudden decrease followed by a slow recovery requiring several days, and frequently much longer periods. Although the decrease applies to all energies of primary cosmic rays,

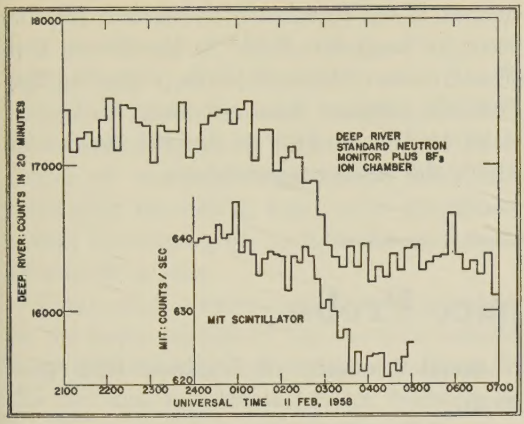

Fig. 3. *Cosmic-Ray Counting-Rate Records for Neutron Monitor and Ion Chamber at Deep River, Canada, and for Scintillation Counter at the Massachusetts Institute of Technology. The "precursor" appears at 0127 UT; the major decrease begins at approximately 0200. Canadian information by courtesy of Hugh Carmichael; scintillator information from Palmeira and Williams,* Il Nuovo Cimento, *Vol. III, 1958, p. 352.*

the low-energy part of the spectrum is affected to a larger extent than the high.)

Another feature of the Forbush-type decrease, which seems to have been reported for the first time in this event, is a "precursor" drop in intensity that occurred closely coincident with the sudden commencement of the magnetic storm, at 0127 UT. As shown in Figure 3, the precursor drop is about 0.5% in the scintillation-detector record and 1% in the neutron-monitor and ion-chamber record. Both records show an apparent increase in intensity just before the precursor. The major decrease occurred between 0200 and 0330 UT and was completed by the end of the "first phase" of the magnetic storm, at the same time that H at Fredericksburg (Figure 1) dropped below the prestorm level.

High altitude soundings with a standard ion chamber and counter were taken before, during, and after the decrease. The total influx of cosmic-ray energy, obtained by integrating the ion chamber rates throughout the atmosphere, dropped 14.9% during the storm; by February 16 it had recovered to within 8.4% of the February 8 value.

Discussion

All the phenomena described are consistent with the passage of the earth into a remarkably intense solar cloud. This cloud may have originated in the solar flare beginning at 2108 UT February 9 and ending at 2302 UT February 9. According to the magnetic records, the terrestrial disturbances began at 0127 UT February 11, and by 24 hours later had fallen to a low level. It may be assumed that the earth was clear of the cloud by that time.

If the cloud originated within the two-hour interval of the flare and required 24 hours to pass the earth, considerable velocity dispersion must have been present in the solar gas. The velocity range of particles in the cloud must have been about 700 to 1400 km/sec, and the radius of the cloud when passing the earth about 0.5 astronomical units (the distance from earth to sun). The minimum lateral extent, estimated from the angular position of the flare with respect to the sun-earth line, was about 0.25 astronomical units near the earth.

The velocity dispersion requires that the slower solar particles predominate later in the storm. The leading edge of the cloud must have been exceedingly well defined and on the order of an earth radius across. The cloud must also have contained considerable internal structure, as revealed by the "spikes" in the first phase and by the two large bays accompanying the X-ray bursts later in the storm. These structural features must have persisted during the sun-earth passage despite the large velocity dispersion.

The process of tracking these features back to a specific series of events in the flare would be extremely difficult. Nevertheless, it is possible to conclude that either the flare emitted considerable matter in very discrete velocity groups, or that a non-linear propagation effect intensified certain portions of the stream, in particular the leading edge and several internal regions.

This storm is unique with respect to the great intensity of the associated ionospheric

phenomena; this may reasonably be attributed to an exceptionally high density of the solar gas enveloping the earth. In contrast, the modulation of galactic cosmic rays, while appreciable, is in no way exceptional when compared with other Forbush-type decreases. If the cosmic-ray decrease is attributed to magnetic fields in the cloud, the effectiveness of these fields in producing the Forbush decrease does not seem to be related to the amount of ionized matter in which the fields are contained.

First Deep Space Probe

The first probe into deep space was launched from Cape Canaveral, Florida, at 3:42 pm EST on October 11, 1958. Though it did not reach its maximum objective, the environs of the moon, the space probe, named Pioneer, reached a record altitude of approximately 72,800 mi (63,200 nautical mi) and telemetered much scientific information to earth.

The probe was launched by the Air Force Ballistic Missile Division, under the direction of the National Aeronautics and Space Administration, as a contribution to the National Academy of Sciences' IGY program.

Launching: The launching vehicle was a four-stage rocket with a total length of 88.1 ft and weighing approximately 112,000 lbs. The first stage, or booster, was a standard Thor, about 61 ft long, 8 ft in diameter, and weighing approximately 106,600 lbs. It develops about 150,000 lbs of thrust. The second stage was a modified Vanguard second stage, a liquid-fueled rocket 18 ft long, 32 inches in diameter, weighing 4612 lbs. I

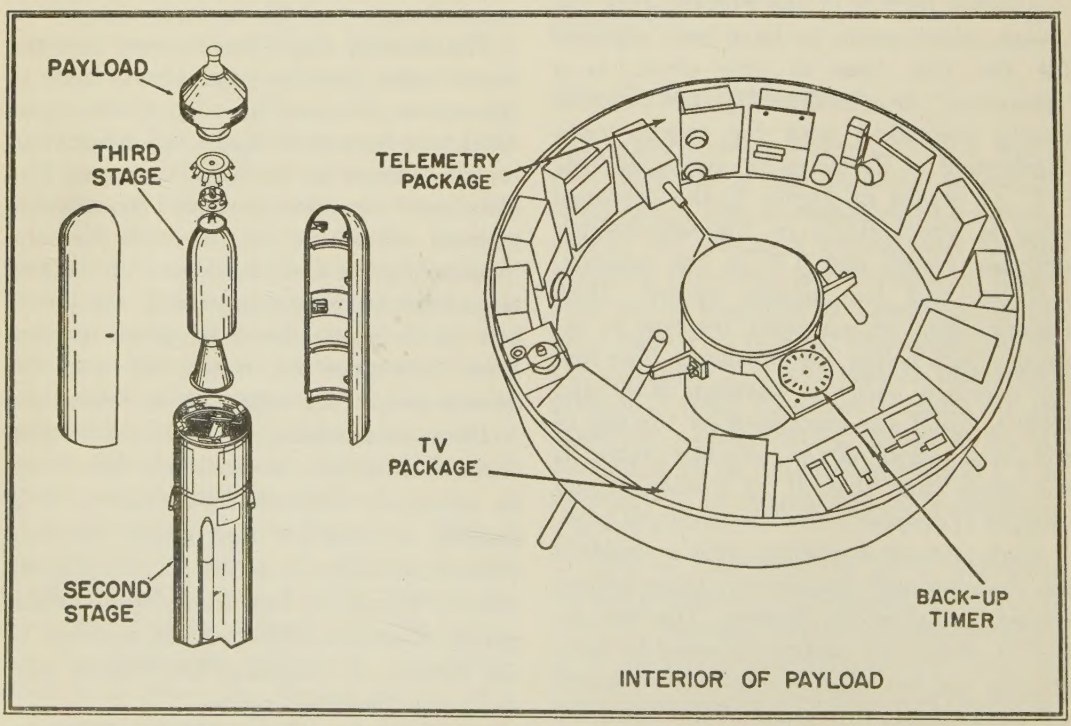

Fig. 4. *Upper Stages and Payload of Pioneer Space Probe. Prepared by Space Technology Laboratories.*

develops a thrust of 7700 lbs. The third stage was an advanced version of the Vanguard third stage, a solid-propellant rocket five ft long, 24 inches in diameter, weighing 597 lbs, and developing about 3000 lbs of thrust. A fourth or terminal stage, to be fired 2.61 days after launching, was a solid-propellant rocket developing up to 2200 lbs of thrust. It was 30 in long.

Eight small vernier rockets were attached to the lower portion of the terminal vehicle to impart velocity and vector corrections to the payload immediately after burnout of the third stage. Spin stabilization of the payload was accomplished by means of spin rockets.

A velocity of 35,250 ft/sec had been planned for the probe. However, because Pioneer traveled about 3.5° above the designed flight path, the actual velocity attained was about 34,400 ft/sec.

Payload characteristics: The toroidal-shaped payload, pierced by the terminal-stage rocket, was 29 inches in diameter and weighed 85 lbs (see Fig. 4). The weight of the instrument package itself was approximately 39 lbs. Pioneer was constructed of Fiberglas, and was painted in a special pattern as a means of controlling temperatures.

Instrumentation: Pioneer carried instrumentation to measure radiation encountered in space; the magnetic field of the earth and of the moon; density of meteoric matter in the payload's flight path; temperatures within the scientific package; and to obtain a crude electronic picture of the surface of the moon—the so-called TV scanner.

The ion chamber used to measure radiation was built to a design developed by James A. Van Allen and Carl E. McIlwain at the State University of Iowa. The Air Force Cambridge Research Center designed the micrometeorite equipment, which was built by the Space Technology Laboratories. STL, designer and producer of Pioneer, had responsibility for over-all scientific direction of the probe. STL also developed the magnetometer and temperature experiments. The scanning system was developed by the Naval Ordnance Test Station, China Lake, California.

Preliminary inspection of the scientific data by Van Allen and his associates at State University of Iowa indicates that the probe may have traversed the Van Allen radiation belt as it penetrated into space; temperatures within Pioneer remained within the range of human survival, if not comfort. More detailed reports of these and other experiments will be made available to the scientists of the world as soon as possible.

Tracking: Five prime stations tracked the Pioneer. They are located at Manchester, England (the Jodrell Bank radio telescope of the University of Manchester); Singapore, Malaya; Hawaii, T. H.; Cape Canaveral, Florida; and Millstone, Mass. All but the Singapore station were equipped to obtain positional data on Pioneer, and all stations recorded telemetry data. These stations, and the NASA Minitrack stations (via the NRL operations center at Cape Canaveral), funneled their information to the Data Reduction Center of STL at Inglewood, California.

The Hawaii prime tracking station was last to have contact with Pioneer, at 10:46 pm EST, October 12, 1958, as it fell back toward the earth. The probe presumably disintegrated in the earth's atmosphere over the South Pacific shortly thereafter.

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